DENSO: Optimizing Transportation with Quantum Computing

CASE STORY

Using quantum to make the future of urban transportation faster, smoother, and more sustainable.

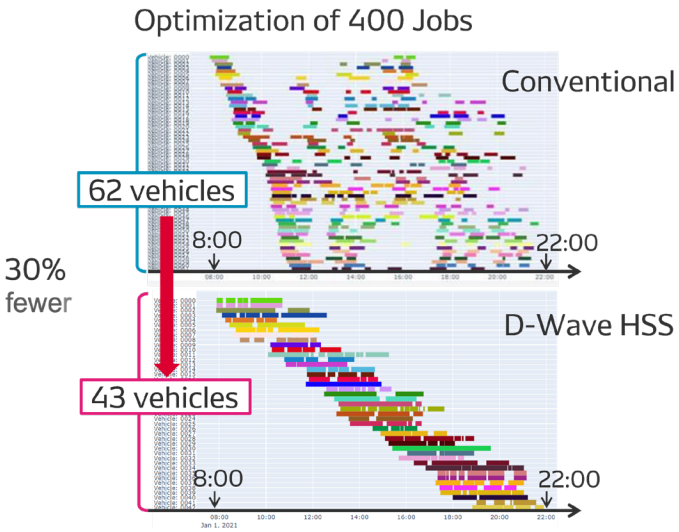
Taxis and ride-sharing services are an essential resource for traversing many of the world's cities. But dispatching is far from an exact science, and it can be difficult to ensure that there are sufficient vehicles at the right place and time to minimize the time wasted both by drivers and the prospective passengers waiting on them.

Technologies for facilitating "connected driving" are a major priority for the DENSO CORPORATION, a leading global manufacturer of automotive parts. To this end, the company has recently embarked on a number of projects that demonstrate how D-Wave's hybrid quantum computing systems can boost the efficiency—and sustainability—of urban transportation.

Tourists are heavy users of taxis, and many passengers use their rides as an opportunity for sightseeing while en route to their eventual destination. In one recent study, DENSO researchers used advance scheduling data from sightseeing taxi routes in Kyoto as a test-bed for quantum optimization. They looked at 400 prebooked taxi trips over the course of a full day, and compared the efficiency of a conventional scheduling system relative to the D-Wave™ platform in terms of coordinating car dispatch.

The difference was stark. Only 43 taxis were required to tackle these 400 rides in the D-Wave-derived solution, versus 62 vehicles with the traditional approach—a 30% reduction in vehicle demand.

A second study, conducted in the Bangkok area in conjunction with Toyota Tsusho Mobility Informatics in Thailand, provided further proof of these efficiency gains. When the DENSO team employed D-Wave's quantum hybrid solver, they were able to devise greatly improved routes for a relatively small fleet of 18 vehicles. With a quantum assist, those vehicles were able to hit the same number of stops while cutting both their mileage and driving time by nearly 10%.



30% FEWER VEHICLES REQUIRED WITH D-WAVE

This isn't simply a matter of saving time and effort—these efficiency gains could also slash the carbon emissions associated with all of these taxi rides. DENSO is also looking into other opportunities to apply quantum computing in the service of making urban transport more environmentally sustainable. This includes alternative ride-sharing models that could mitigate the carbon footprint of ride-share services, including "multi-modal transportation" systems that combine multiple vehicle categories. For example, riders heading to a popular destination might be relayed via individual cars to shuttles or buses that transport them collectively to their next stop in an energy-efficient and traffic-minimizing fashion.

Managing such a complex transportation network could quickly become a logistical headache, but a preliminary study by DENSO shows how D-Wave's quantum computing platform could help formulate efficient routing strategies in such scenarios.

To formulate a model, the researchers devised a scenario in which multiple cars pick up multiple guests at a variety of locations, and then relay them to a junction where a shuttle waits. This shuttle then takes the gathered riders to another junction, where they are picked up by another set of taxis and taken to various other destinations. The DENSO team formulated this same problem in a range of conditions with variable numbers of cars, passengers, and pick-up stops per car.

The researchers then compared the performance of the D-Wave BQM and CQM solvers in tackling this challenge relative to one of the most popular, state-of-the-art classical solvers. All three performed roughly similarly when the total number of variables was relatively small, but D-Wave's constrained quadratic model (CQM) solver quickly distinguished itself as the number of variables grew.

By the time the two systems were grappling with scenarios involving 256 passengers, the CQM solver was yielding routing solutions that were 26% more efficient than those generated by the conventional solver. The amount of computing time required increased along with the complexity of the scenario, but the DENSO team found that they could address this by pursuing solutions that were just slightly less than ideal. By sacrificing 10% of the efficiency of the optimal solution, the CQM solver could tackle high-complexity routing calculations more than 100 times faster.

Collectively, these analyses show how DENSO and other leaders in the automotive industry can leverage cutting-edge quantum computing capabilities to make the future of urban transportation faster, smoother, and more sustainable. For more information, see the video talk from DENSO or the presentation on this work.

ROUTE OPTIMIZATION FOR MULTIMODAL TRANSPORT SYSTEMS (LATEST RESULTS BY D-WAVE HSS)